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## DC power for data centres

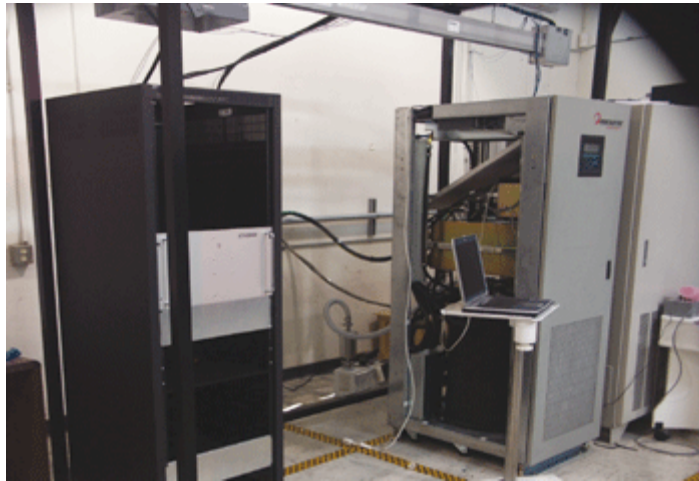
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About a year ago, a diverse group of researchers and industry data center professionals met at Pentadyne's manufacturing facility in Southern California to explore whether direct current (DC) power distribution would be advantageous in a data center environment. What they saw was a prototype system that could be assembled with commercially available components that could deliver high voltage DC. The group discussed whether it would be feasible and whether there would be a benefit to directly supply high voltage DC to servers. The industry participants, consisting primarily of server manufacturers and suppliers of electrical distribution equipment quickly developed consensus that a DC solution was viable and would result in important energy

savings.

Lawrence Berkeley National Laboratory (LBNL) and its consultants, Ecos Consulting and EPRI Solutions had recently completed studies that concluded that there was a large energy saving potential inherent in the power conversions that occur in data centers. Specifically they had studied the range of efficiency in server power supplies and UPS systems. In both cases, a wide range of efficiencies were observed which suggested that dramatic improvement could be made if the market could be moved to the higher performing components. While this is still a viable strategy, the team was quick to embrace the even more aggressive solution of eliminating some of the conversions in the overall power delivery scheme and they devised a demonstration project that would show how this could be accomplished today. Through its sponsor, the California Energy Commission's Public Interest Energy Program (PIER), the LBNL team helped to organize the interested industry participants to participate in the demonstration.



Prototype system at Pentadyne facility

In April 2006, the team met to develop plans for the demonstration and the wheels of progress turned quickly in obtaining commitments for equipment and services that would be contributed by the industry players. In May, equipment was being delivered to the demonstration site - a Sun Microsystems manufacturing facility in Newark, CA. Both Sun Microsystems and Intel Corporation began work on modifying power supplies in conventional servers so that they could directly accept 380 volt DC - the consensus voltage agreed to by the team. In June, all of the equipment necessary to demonstrate the comparison of equally sized, facility level, AC and DC distribution systems was provided and installed. Later, a "rack level" demonstration was also supplied. In both schemes, commercially available, UL rated equipment rated for 380V. DC was used wherever possible.



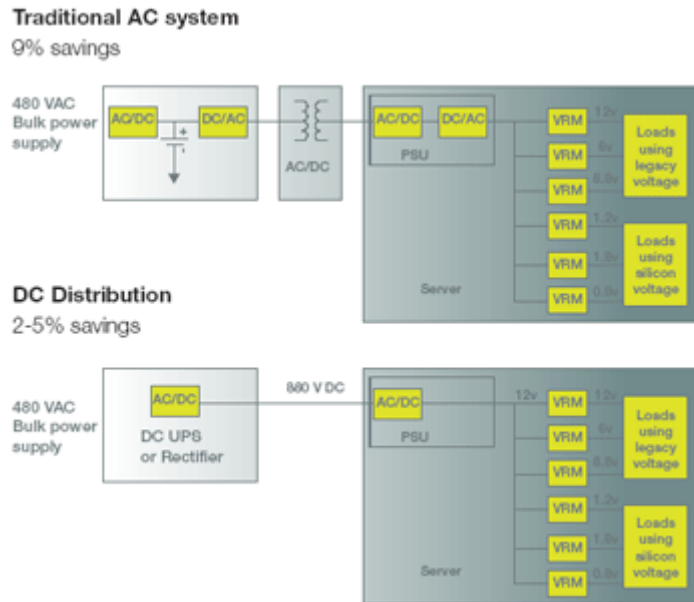


DC and AC demonstration systems at Sun Microsystems

Over the summer, twelve “open house” sessions were held where industry representatives and the general public could get an overview of the technology and results, view the demonstration equipment, and discuss the implementation ramifications of this technology. Now, the results are in, the demonstration equipment has been returned, and a report of the findings is being prepared.

### Results of the Demonstration

**Energy Savings** The figures below illustrate the facility level electrical distribution schemes that were demonstrated and the energy savings that were measured.



In the demonstration, electrical power was measured continuously on either side of each power conversion step for both the conventional AC system and the DC system using a state-of-the-art monitoring system provided by Dranetz-BMI and the performance was viewable on-line. Both systems had identical servers performing identical computing although the supplies for the DC system had the front end power supplies modified to accept 380V DC. As shown above, better than 10% energy savings was measured in this demonstration. However, the AC system used for comparison was in itself a highly efficient system. Two different UPS systems were supplied and the monitored performance of each was far better than typical systems benchmarked in the prior study. So if the DC system in the demonstration was compared to typical systems in use today the efficiency improvement could have been much greater - perhaps greater than 20%. Since all electrical energy consumed in a data center results in heat, there is also large electrical power consumption in the HVAC systems required for cooling. Prior benchmarking has shown that HVAC power consumption is on the same order of magnitude as the power supplied to the IT equipment so a 20% saving in the power flowing to IT equipment also results in a 20% saving for the HVAC equipment - or an overall Facility power reduction of 20% - a very significant reduction for today's energy intensive centers.

### Reliability

The demonstration team's opinion concerning reliability of a DC distribution system was that overall reliability should be improved over traditional AC systems. By removing some of the conversion steps there are fewer potential points of failure in the DC system. Other DC systems used in telecom facilities (e.g. 911 system), and other industrial applications such as transportation, elevators, military applications, etc. have a history of reliable service. Battery systems have had reliability problems especially if poorly maintained however the underlying DC systems have been extremely reliable.

By eliminating heat from the IT equipment (power supplies) and the data center (UPS systems), the ability to cool the equipment will be

enhanced resulting in better reliability of the IT equipment. Failure of IT equipment is often tied to overheating due to the inability to provide uniform cooling.

**Total cost of Ownership**

Although a rigorous cost comparison was not a part of the demonstration, there was considerable discussion about cost at the various open house meetings. The consensus of the team was that the energy savings could easily justify the cost of the system - return on investment - in very short timeframes. In the long run, the first cost of the DC systems could be lower than their AC counterparts due to fewer components in the system. In addition there may be more space available on the computer room floor.

**Open Issues**

The demonstration team agreed that a DC distribution voltage of 380V. would be appropriate. Now, a consensus of the industry is needed if the technology is to move forward. There is a unique opportunity to establish a world-wide consensus and avoid the problems of multiple infrastructure requirements. Server manufacturers and other equipment suppliers do not want to provide equipment for multiple voltages if this can be avoided.

Another issue which resolution would hasten the adoption of DC power in data centers is in standardizing the DC connection to the IT equipment. Analogous to the AC line cords and power strips on servers and other AC powered equipment today, there needs to be a standard for attaching to a DC system. Hot swappable connectors for 380V. DC systems are available however a standard configuration for widespread use is needed. The LBNL team plans to address these open issues.

**About the author**

Bill Tschudi is a Program Manager for the Applications Team which is part of the Environmental Energy Technologies Division at Lawrence Berkeley National Laboratory (LBNL). The Applications Team is tasked with bridging researchers and real world application of emerging technology. Bill currently is the Principal Investigator leading LBNL's data center and cleanroom energy efficiency projects. These projects involve a number LBNL researchers and a number of subcontractors focused on research, demonstration, and technology transfer activities for these building types. Bill is a licensed mechanical engineer with over 35 years of experience, including 14 years involved with the design of high tech and mission critical facilities. He is a member of ASHRAE and participates in Technical Committees TC9.11 - Cleanspaces and with the data center committee, TC 9.9 - Mission Critical Facilities, Technology Spaces and Electronic Equipment. Prior to joining LBNL, Bill managed multi-disciplined engineering offices for leading firms in the design of data center and clean room facilities. Prior experience also included engineering management for industrial and power projects.